“SPACE MEDICINE”

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NASA Johnson Space Center

Houston

The first word from the Moon

OBJECTIVES

-DISCUSS SCOPE OF NASA MEDICAL OPERATIONS

-HIGHLIGHT UNIQUE PREVENTIVE MEDICINE ASPECTS OF SPACEFLIGHT

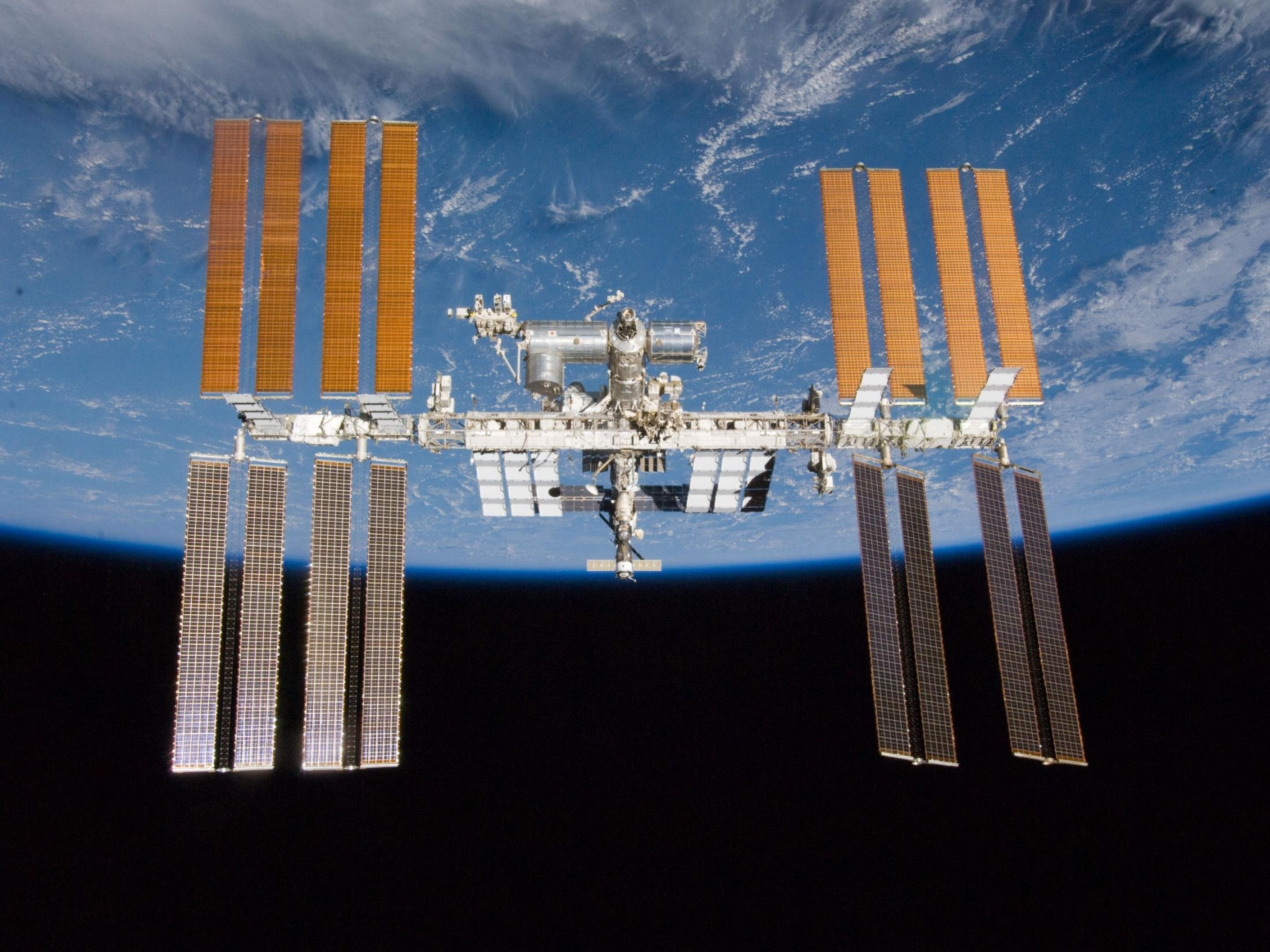
-NOTE CHALLENGES FOR CARE IN EXPLORATION CLASS MISSIONS

Medical Operations Responsibility

To ensure the health, safety, and well being of the Astronaut corps during all phases of spaceflight.

Soyuz Landing Deployment Schematic

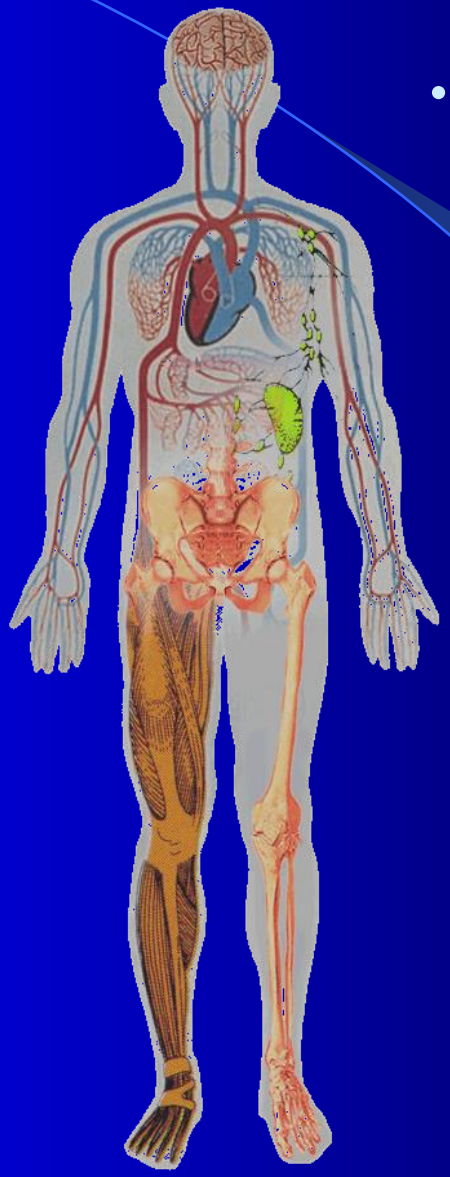
National Aeronautics
and Space
Administration



Human Response to Spaceflight

Astronauts experience a spectrum of adaptations in flight and postflight

Balance disorders
Cardiovascular deconditioning
Decreased immune function
Muscle atrophy
Bone loss



- Neurovestibular
- Cardiovascular
- Bone
- Muscle
- Immunology
- Nutrition
- Behavior

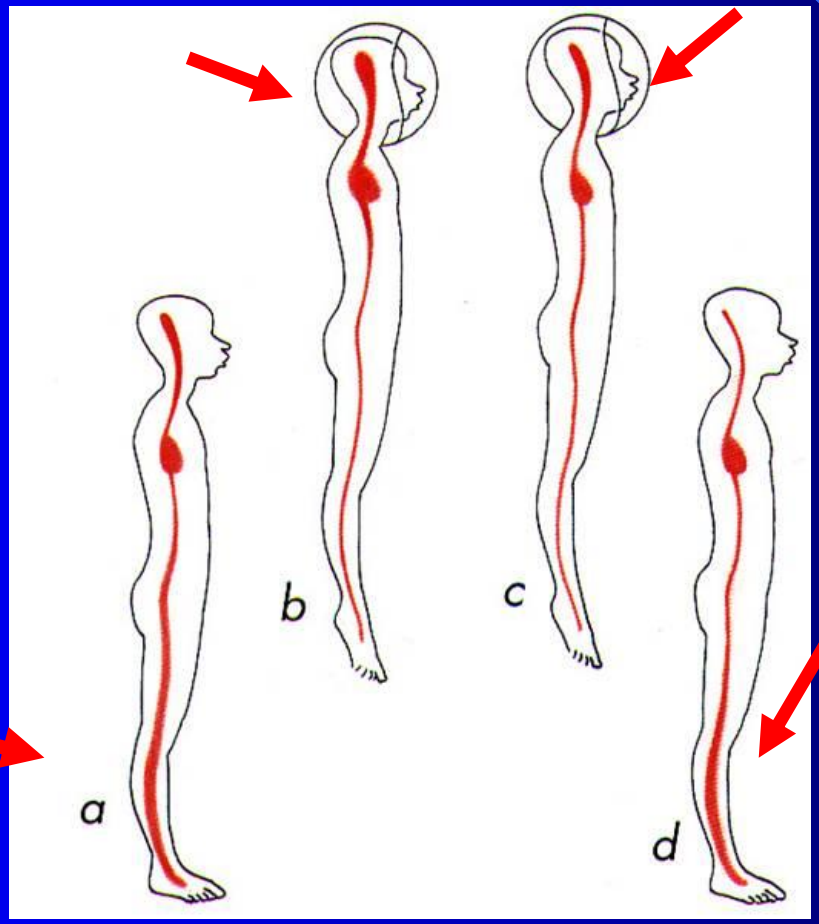
Hazards of Space Flight

- Space Environment
  - Reduced Gravity
  - Radiation
  - Vacuum
  - Debris
- Spacecraft Environment
  - Isolation and confinement
  - Noise and Vibration
  - Closed loop environment (life support)
  - Payloads and construction activities
  - Waste production
- Space Flight Mission
  - Flight activity; Launch and Reentry Forces
  - Remoteness and communication access
  - Circadian rhythms and crew schedule changes
  - Extravehicular Activity (EVA)
  - Decompression Sickness

Fluid Shifts and Blood Volume during Space Flight

In space, with loss of the hydrostatic gradient, some fluid quickly redistributes toward the chest and upper body; sensed as 'overload' of circulating blood volume

In space, the newly sensed excess blood volume is adjusted by expelling excess fluid into tissues and cells (**12% to 15% vol reduction**) and red blood cells are adjusted downward to maintain a normal concentration (**relative anemia**)



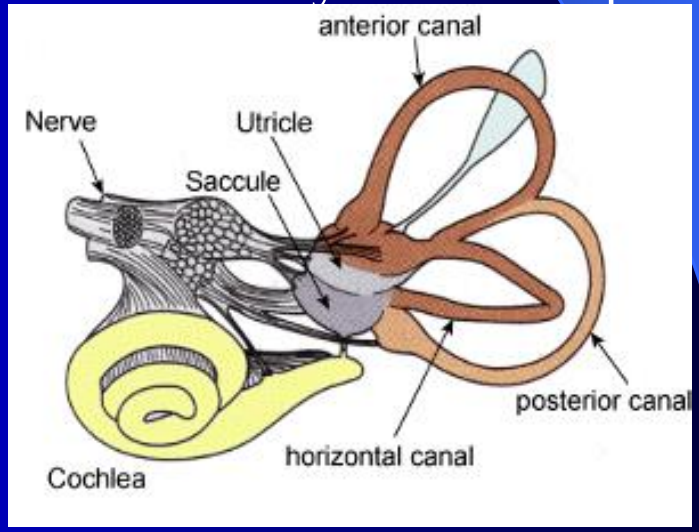
On Earth, gravity exerts a downward force, setting up a vertical hydrostatic gradient. When standing, some 'excess' fluid resides in vessels and tissues of the legs.

Upon return to Earth, gravity again pulls the fluid downward, but now there is a relative deficit In both circulating fluid and red blood cells. Tissue edema also contributes to a greater loss of volume

National Aeronautics and Space Administration

Neurosensory Response

- Sense of balance, position and motion result from centrally integrated inputs from neurovestibular system (otolith organs, semicircular canals), vision, body position sensors, haptic sensors (touch)
- These inputs are immediately and radically altered in weightlessness
- Altered meaning of inputs leads to central sensory conflict – space motion sickness
- Sickness resolves in a few days
- Adaptation continues...



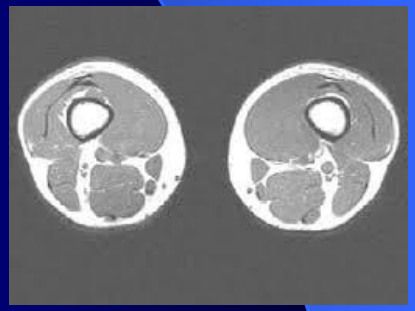
Neurosensory Response

- Eventual adaptation to position sense and motion in three dimensions without gravitational reference
- Sense of ‘up’ or ‘down’ are what you choose to define

National Aeronautics and Space Administration

Musculoskeletal System

- Bone and muscle are vital tissues that are constantly remodeled based on physical loading
- The weightless environment causes a relentless loss (atrophy) of bone and muscle tissue concentrated in the weight bearing regions
- Physical countermeasures on ISS are very good, but not a complete solution



Bone compartments or bone types

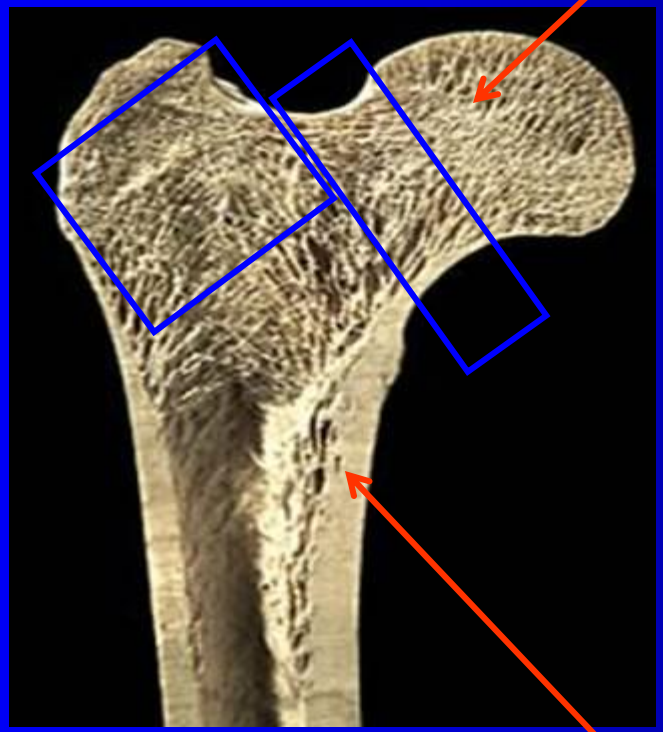
Cancellous "Spongy" Bone/Trabecular Bone

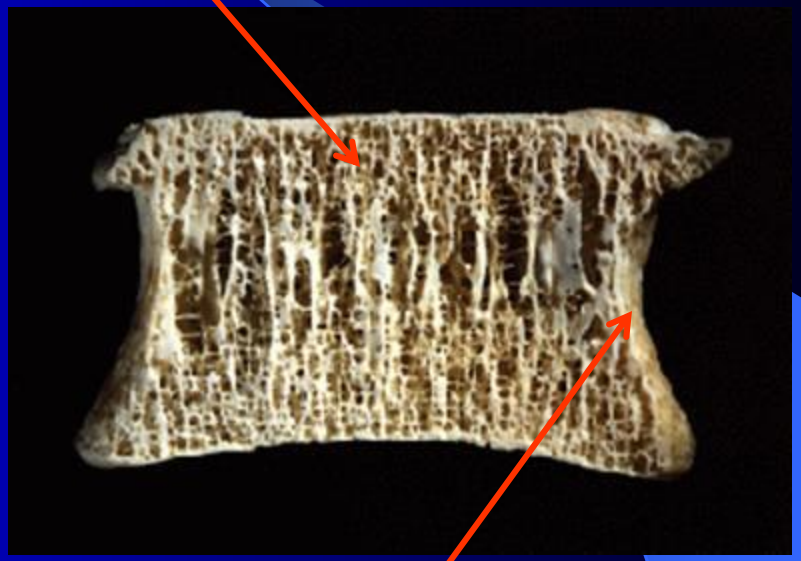
PROXIMAL FEMUR

VERTEBRAL BODY

Trochanter

Femoral Neck





Cortical Bone/ "Compact Bone"

An example of a spaceflight adaptation that is well described but still lacks understanding of time course, recovery, and long term risk

Sources: L. Mosekilde; SL Bonnick; P Crompton


WESTERN KENTUCKY

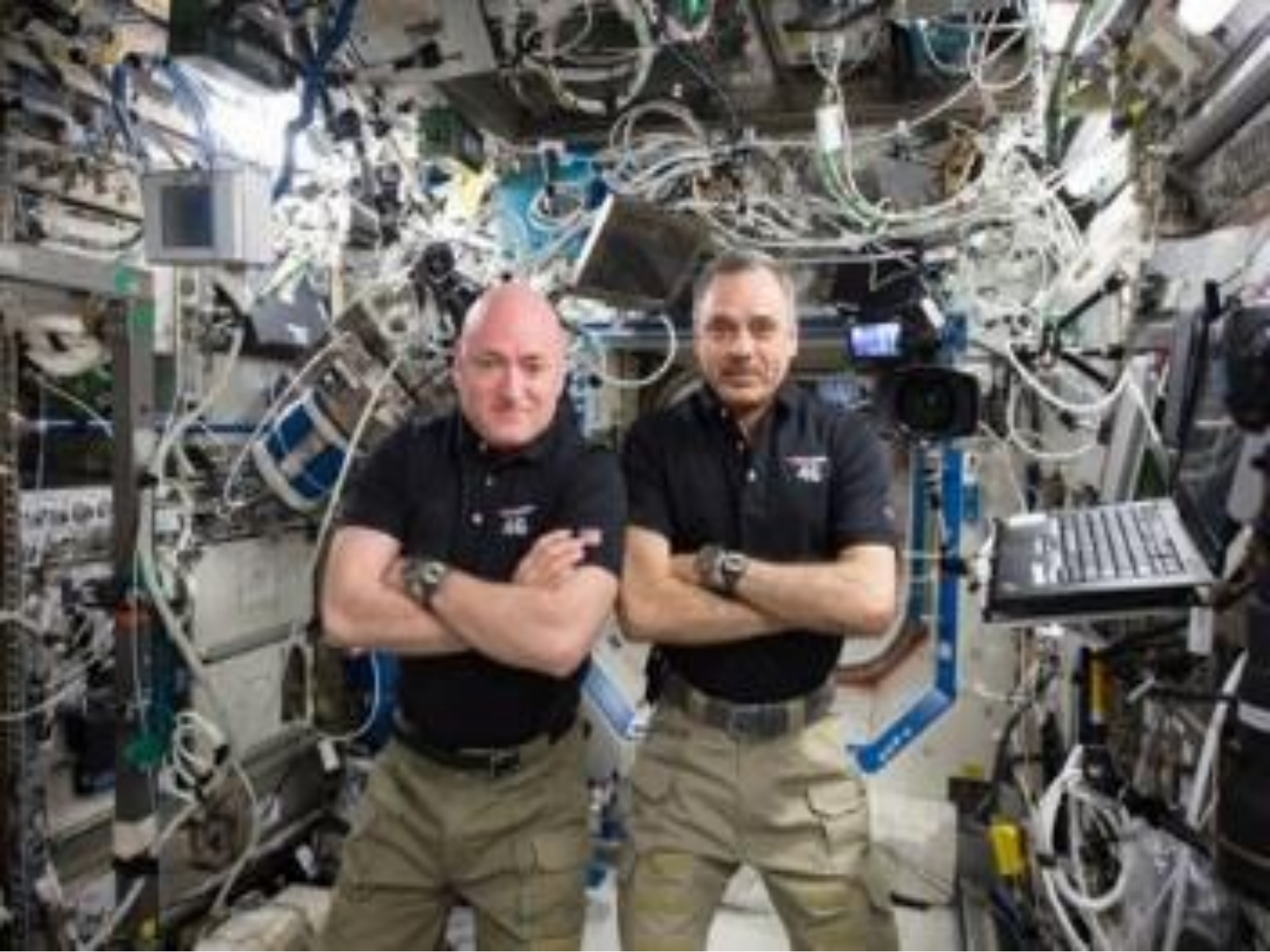
ISS021E035861

ISS020E023075

Behavioral/Psycho-Social

Changes in crew mood, morale, and circadian rhythm

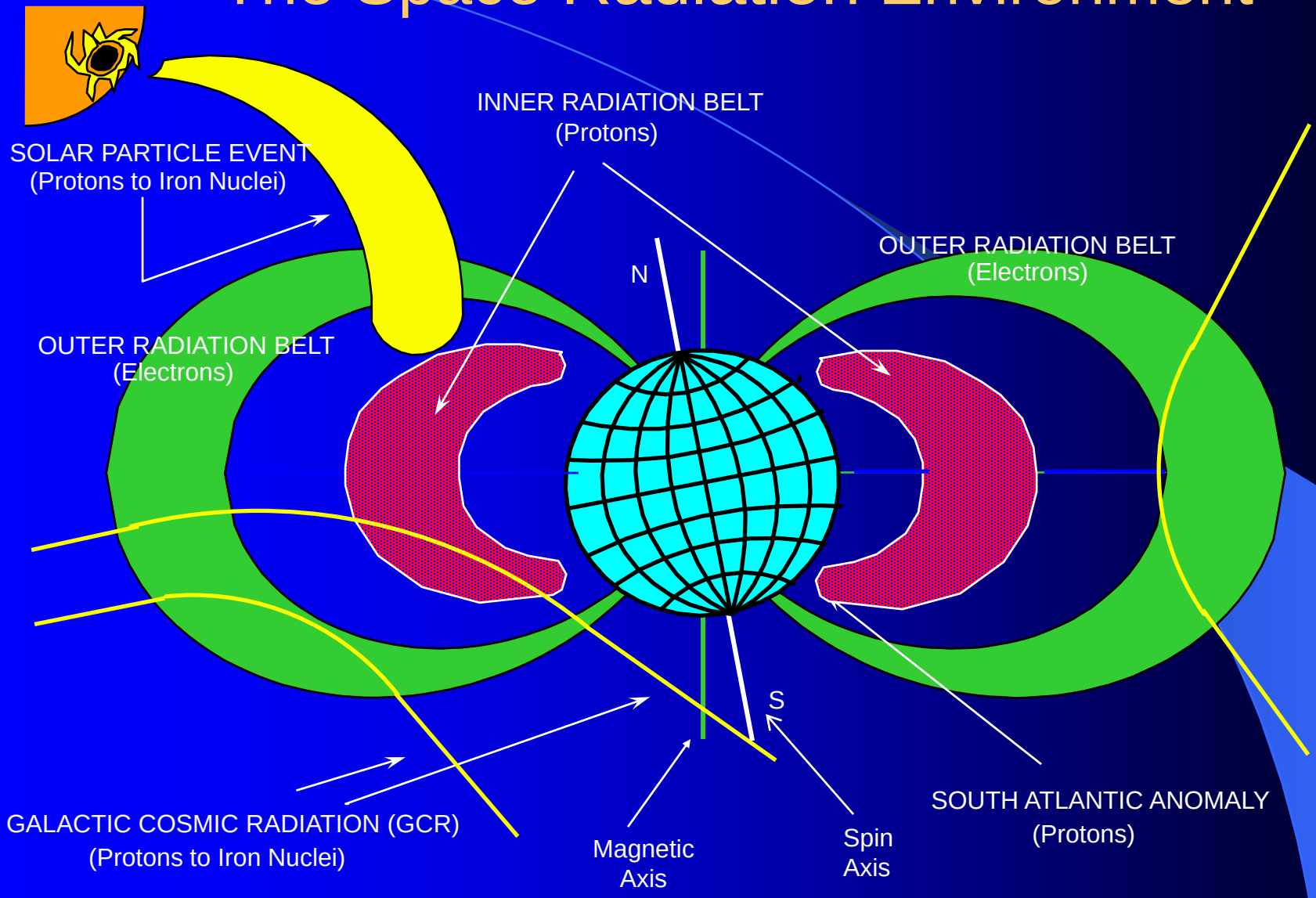
- **Incidence** - Affects all crewmembers to some degree
- **Symptoms** - Fatigue and irritability, performance decrements
- **Time course** - Variable
- **Causes**
  - Work load
  - Sleep habits and facilities
  - Crew personalities, “crew space”, and cultural differences
  - Temperature
  - Noise
  - Odors
  - Atmosphere
  - Diet
  - Lack of family contact
- **Treatment** - Treat causes and maximize living conditions




Оранжерея „СВЕТ"

ISS023E041816

The Space Radiation Environment



Representation of the major sources of ionizing radiation of importance to manned missions in low-Earth orbit. Note the spatial distribution of the trapped radiation belts.

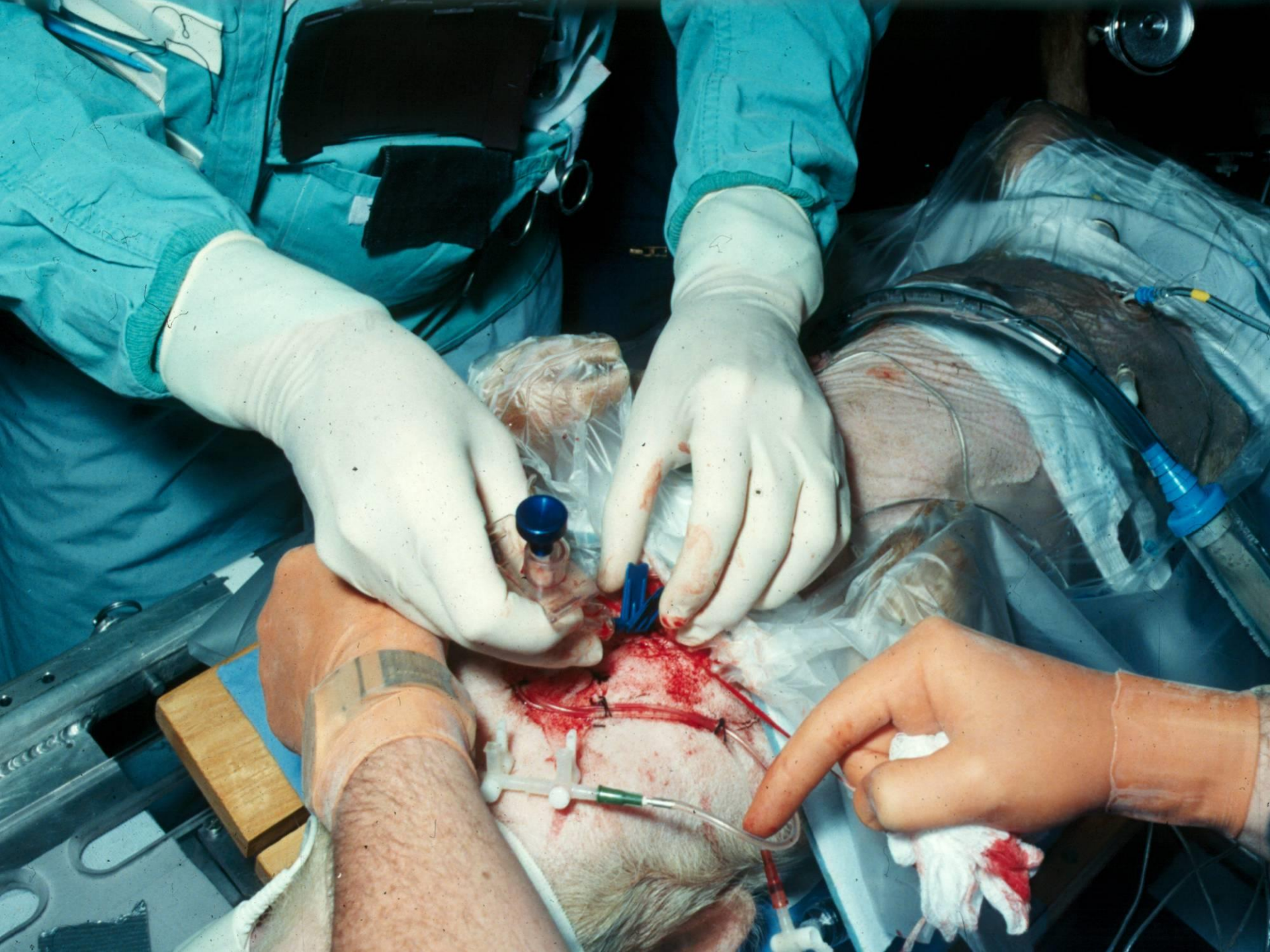

NASA
930

Systems & Crew Training

KC-135
"Weightless Wonder, Vomit Comet"

Hardware Testing and Procedure Validation

Developing Advanced Cardiac Life Support (ACLS) algorithms for on-orbit use and training




NASA

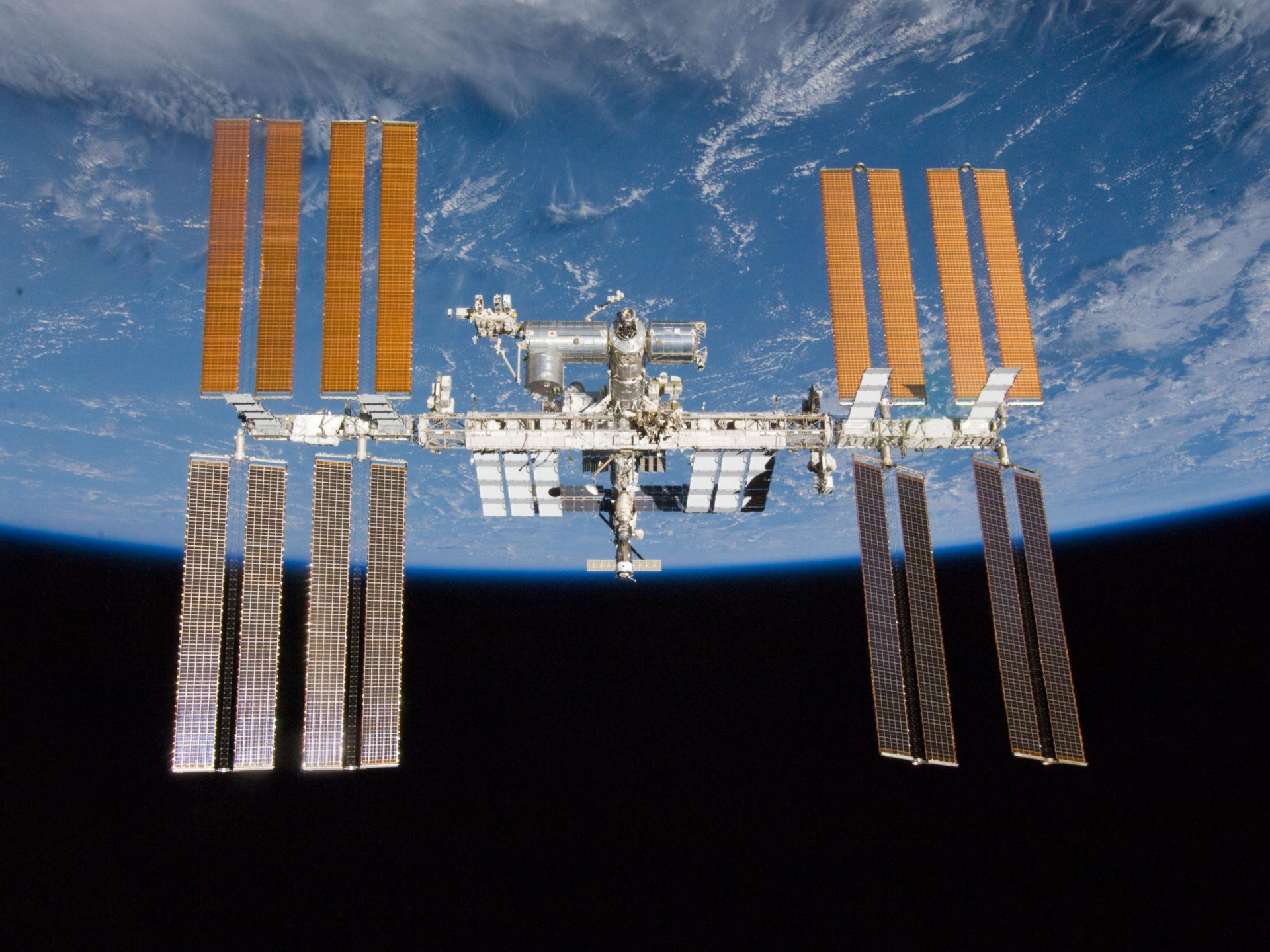
In-flight support

- Private Medical Conferences (PMCs) weekly, 15-minute +, 1-on-1 conferences
  - More scheduled first and last weeks of mission
- Diagnosis and treatment of medical problems that develop onboard
- Analysis of fitness data
- Analysis of environmental data
- Analysis of sleep data
- Workload and work-rest assessments
- Sleep-shift analysis (visiting vehicles & EVAs)
- Family Support

Systems & Crew Training

Shuttle Orbiter Medical System (SOMS)

DRUG SUBPACK

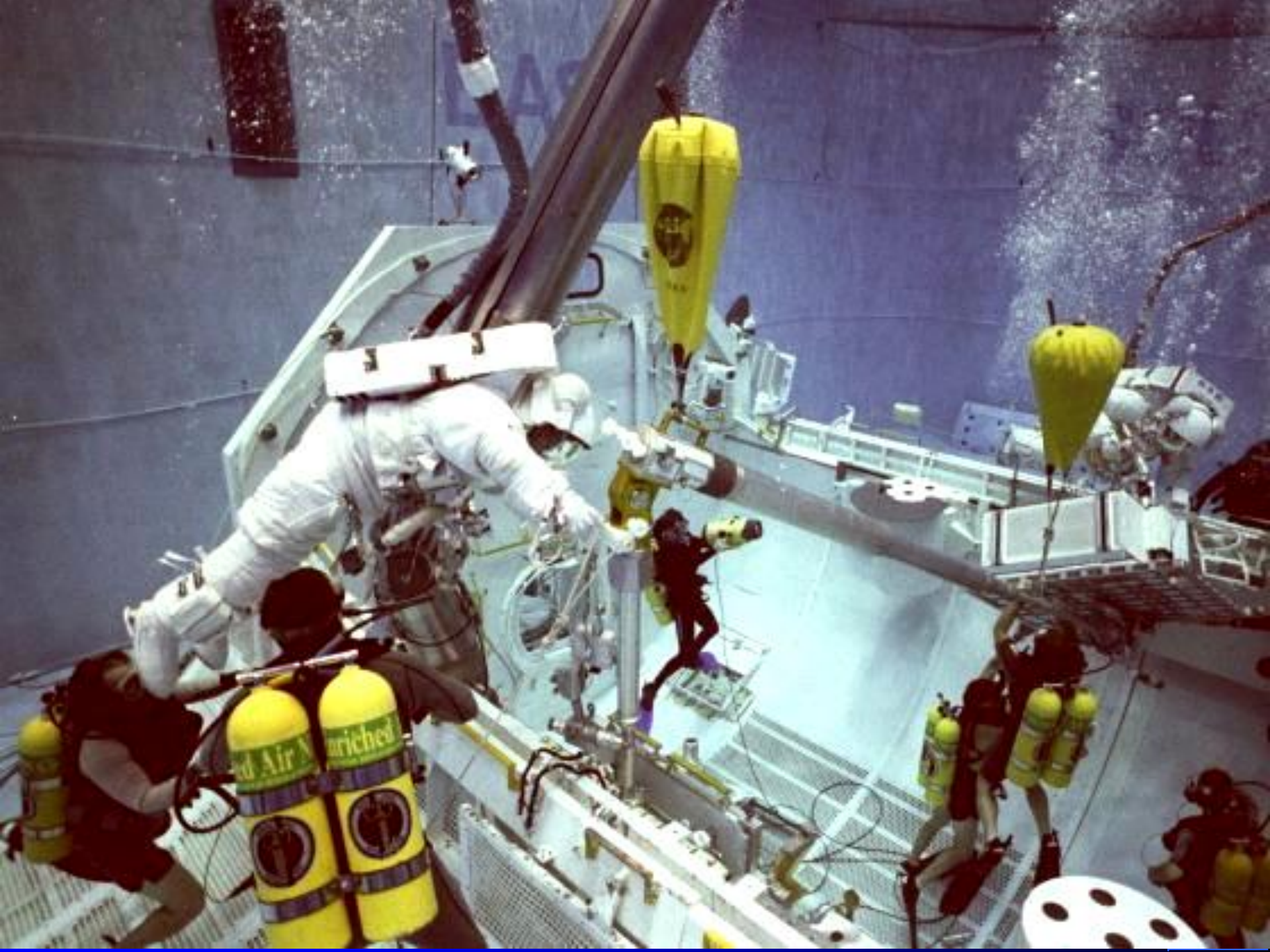


esa
COLUMBUS

Sonny Carter Training Facility, NASA, JSC

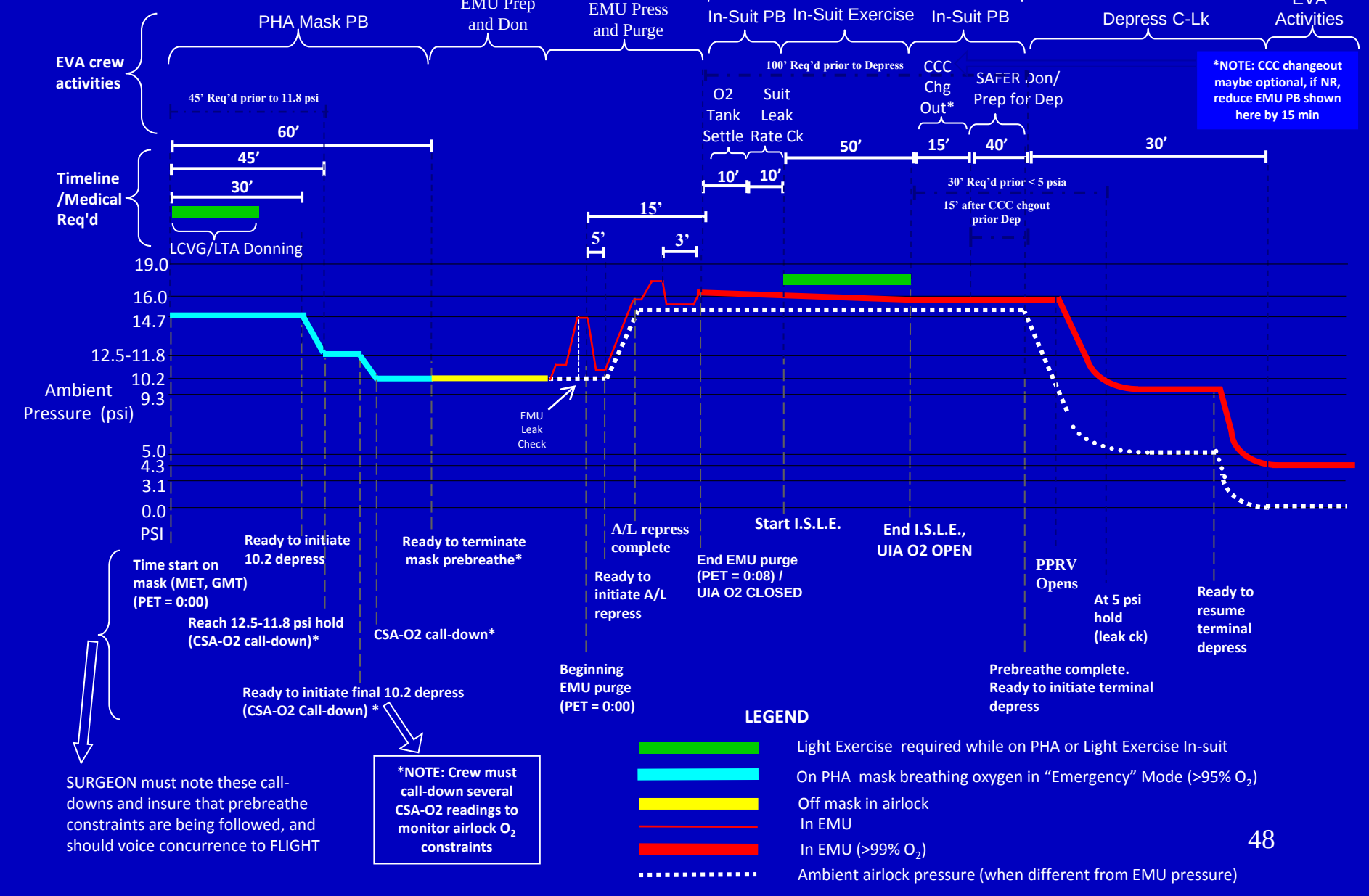

DENAC


1
2



ISLE Pressure Profile (With Data Collection)

Not to Scale

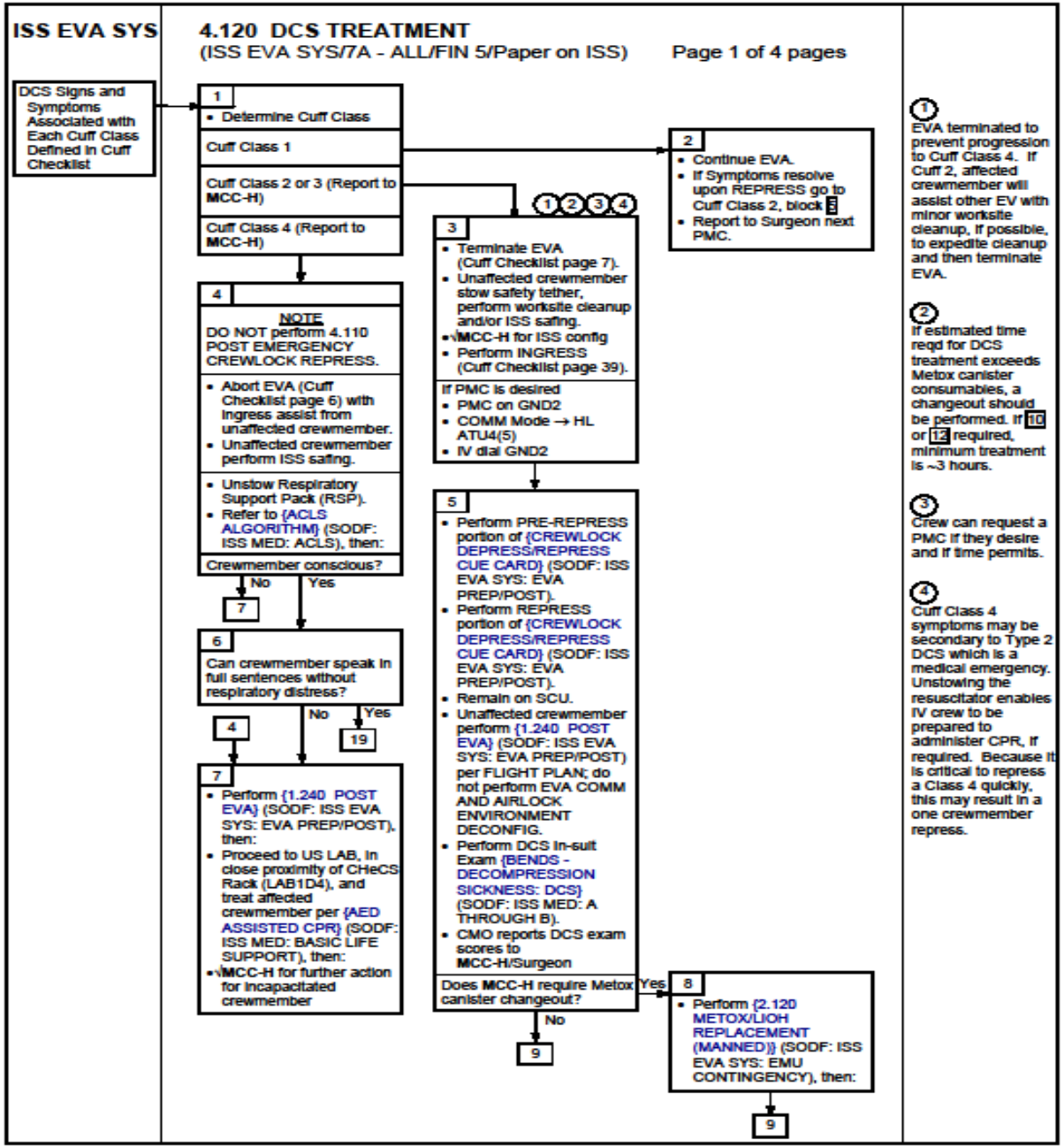


SURGEON must note these call-downs and insure that prebreathe constraints are being followed, and should voice concurrence to FLIGHT

*NOTE: Crew must call-down several CSA-O2 readings to monitor airlock O_2 constraints

LEGEND

- Light Exercise required while on PHA or Light Exercise In-suit
- On PHA mask breathing oxygen in "Emergency" Mode (>95% O_2)
- Off mask in airlock
- In EMU
- In EMU (>99% O_2)
- Ambient airlock pressure (when different from EMU pressure)


ISS EVA SYS
4.120 DCS TREATMENT
(ISS EVA SYS/7A - ALL/FIN 5/Paper on ISS)
Page 1 of 4 pages
DCS Signs and Symptoms Associated with Each Cuff Class Defined in Cuff Checklist
1
• Determine Cuff Class
Cuff Class 1
Cuff Class 2 or 3 (Report to MCC-H)
Cuff Class 4 (Report to MCC-H)
2
• Continue EVA.
• If Symptoms resolve upon REPRESS go to Cuff Class 2, block 3
• Report to Surgeon next PMC.
1 2 3 4
3
• Terminate EVA (Cuff Checklist page 7).
• Unaffected crewmember stow safety tether, perform worksite cleanup and/or ISS safing.
• √MCC-H for ISS config
• Perform INGRESS (Cuff Checklist page 39).
If PMC is desired
• PMC on GND2
• COMM Mode → HL ATU4(5)
• IV dial GND2
4
NOTE
DO NOT perform 4.110 POST EMERGENCY CREWLOCK REPRESS.
• Abort EVA (Cuff Checklist page 6) with ingress assist from unaffected crewmember.
• Unaffected crewmember perform ISS safing.
• Unstow Respiratory Support Pack (RSP).
• Refer to {ACLS ALGORITHM} (SODF: ISS MED: ACLS), then:
Crewmember conscious?
No
Yes
7
5
• Perform PRE-REPRESS portion of {CREWLOCK DEPRESS/REPRESS CUE CARD} (SODF: ISS EVA SYS: EVA PREP/POST).
• Perform REPRESS portion of {CREWLOCK DEPRESS/REPRESS CUE CARD} (SODF: ISS EVA SYS: EVA PREP/POST).
• Remain on SCU.
• Unaffected crewmember perform {1.240 POST EVA} (SODF: ISS EVA SYS: EVA PREP/POST) per FLIGHT PLAN; do not perform EVA COMM AND AIRLOCK ENVIRONMENT DECONFIG.
• Perform DCS In-suit Exam {BENDS - DECOMPRESSION SICKNESS: DCS} (SODF: ISS MED: A THROUGH B).
• CMO reports DCS exam scores to MCC-H/Surgeon
Does MCC-H require Metox canister changeout?
Yes
No
6
Can crewmember speak in full sentences without respiratory distress?
No
Yes
4
19
7
• Perform {1.240 POST EVA} (SODF: ISS EVA SYS: EVA PREP/POST), then:
• Proceed to US LAB, in close proximity of CHeCS Rack (LAB1D4), and treat affected crewmember per {AED ASSISTED CPR} (SODF: ISS MED: BASIC LIFE SUPPORT), then:
• √MCC-H for further action for incapacitated crewmember
8
• Perform {2.120 METOX/LiOH REPLACEMENT (MANNED)} (SODF: ISS EVA SYS: EMU CONTINGENCY), then:
9
9
1
EVA terminated to prevent progression to Cuff Class 4. If Cuff 2, affected crewmember will assist other EV with minor worksite cleanup, if possible, to expedite cleanup and then terminate EVA.
2
If estimated time reqd for DCS treatment exceeds Metox canister consumables, a changeout should be performed. If 10 or 12 required, minimum treatment is ~3 hours.
3
Crew can request a PMC if they desire and if time permits.
4
Cuff Class 4 symptoms may be secondary to Type 2 DCS which is a medical emergency. Unstowing the resuscitator enables IV crew to be prepared to administer CPR, if required. Because it is critical to repress a Class 4 quickly, this may result in a one crewmember repress.

PREVENTION STRATEGY

PREVENTION

Majority of microbial risk mitigation occurs before launch.

- System Design
- Materials Selection
- Engineering controls
  - HEPA air filters
  - In-line water filters
  - Surface disinfectants
  - Water biocides
- Operational controls
  - Preflight Monitoring of Environment
  - Biosafety Review of all payloads
- Extensive preflight monitoring
- In-flight countermeasures
  - Housekeeping
  - Remediation
  - In-flight Monitoring Schedule

Real-Time Samplers

- Compound Specific Analyzer for Combustion Products (CSA-CP)
  - Commercial unit
  - Electrochemical sensor detection
  - First alert and source finding capability
  - Masking criteria after fire

- Multi-Gas Monitor (MGM)
  - Continuous monitoring of humidity, CO2, O2, and ammonia
  - Tunable laser diode sensor
  - Wide dynamic range
  - Stable (greatly reduced need for calibration)

- Carbon Dioxide Monitor (CDM)
  - Commercial unit
  - Infrared absorption used to measure localized CO_2 levels in air

- Air Quality Monitor (AQM)
  - Periodic measurement of volatile organic compounds
  - Gas Chromatograph-Differential Mobility Spectrometry (GC/DMS)
  - Sampling and analysis time is 10-15 minutes

US Water Recovery System

Potable Water Dispenser

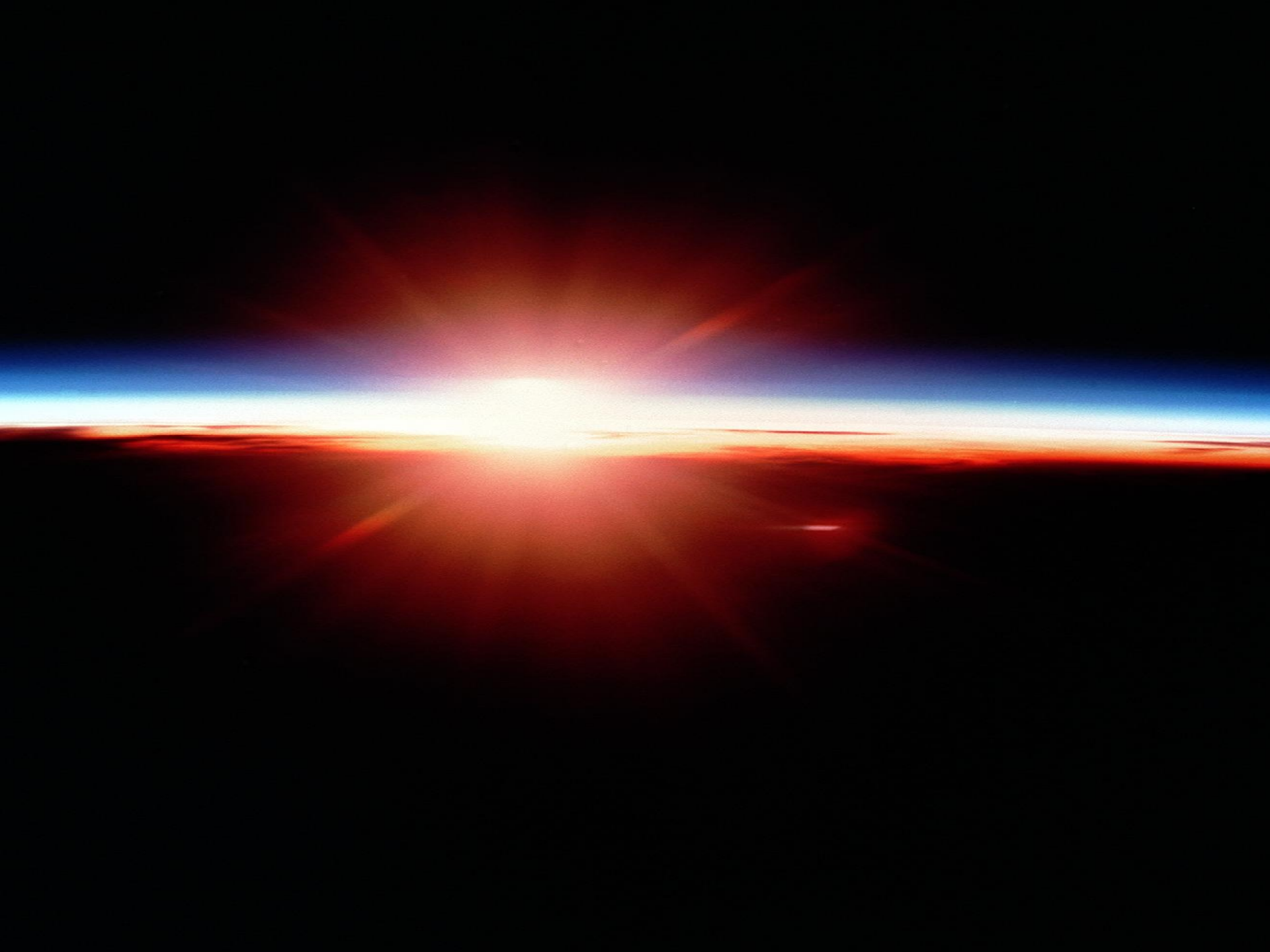
Waste Hygiene Compartment

WRS 1

Urine Processor

WRS 2

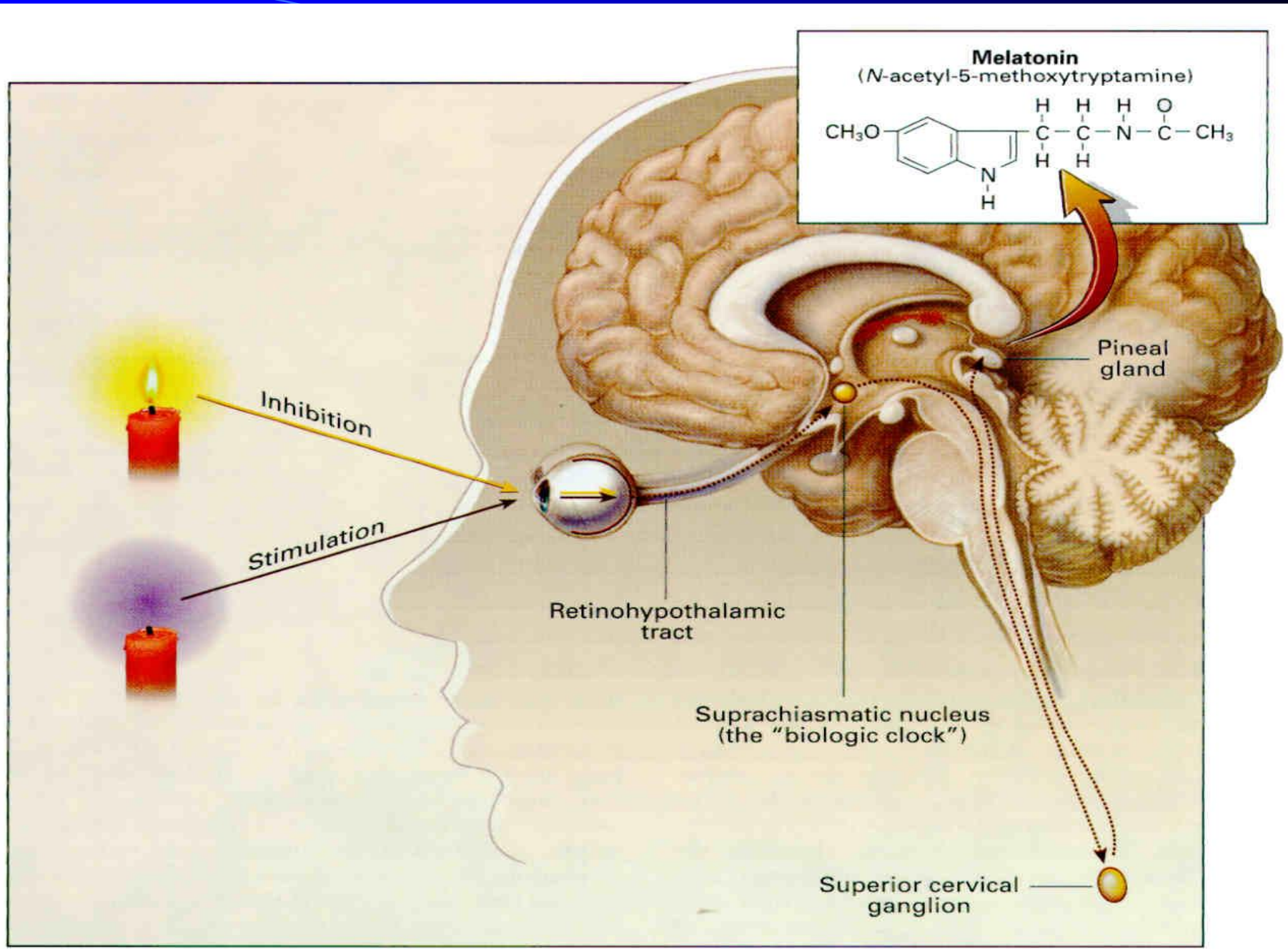

Shuttle air filter debris
Cat. B3062
Scientific Products
Saturated With
Isopropyl Alcohol 70%
For External Use Only
Use to Clean Skin



MF57E

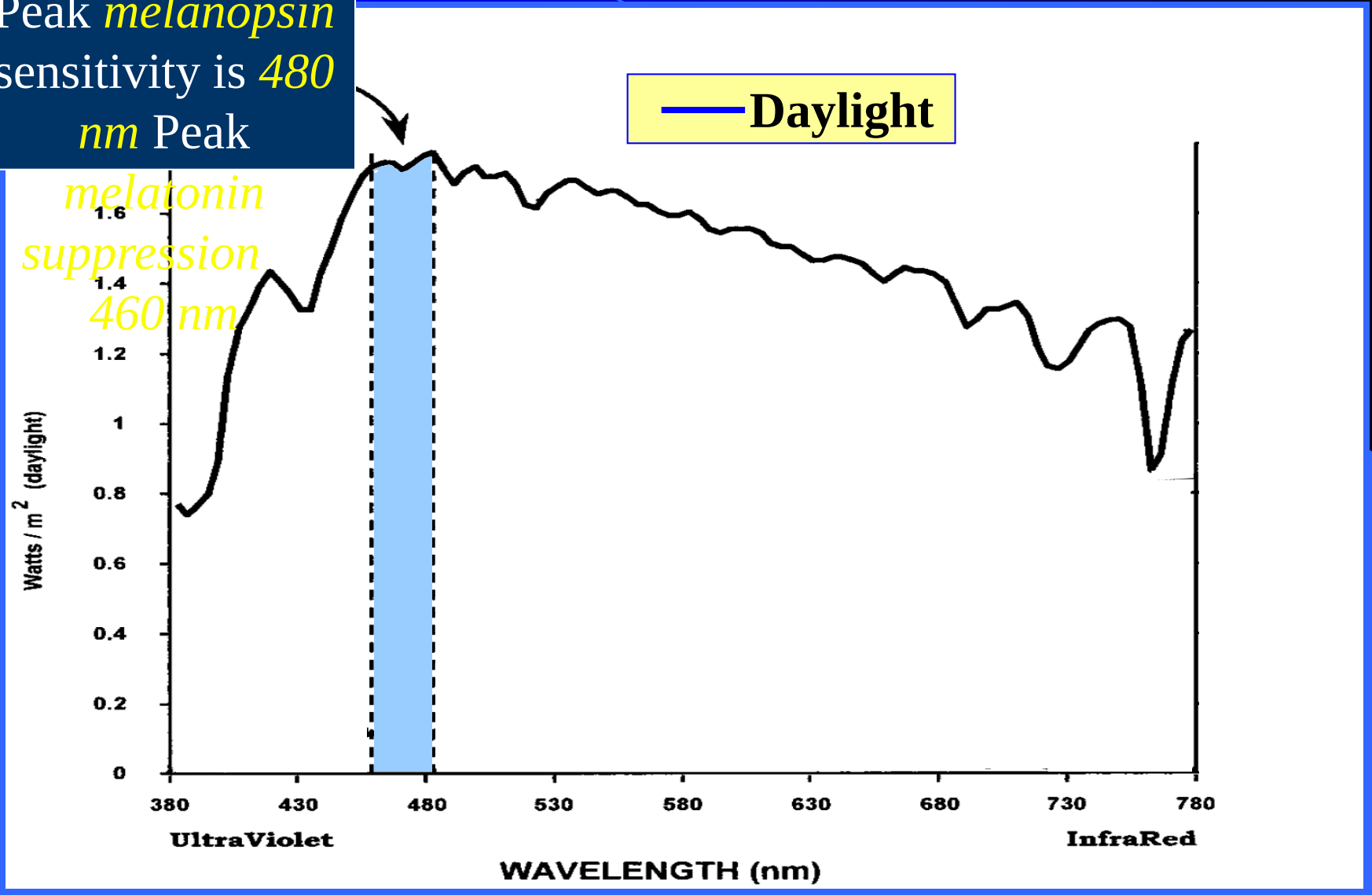
MF71E

MF57K


Melatonin
(N-acetyl-5-methoxytryptamine)
CH3O
H H H O
C C N C CH3
H H
N
H
Pineal gland
Inhibition
Stimulation
Retinohypothalamic tract
Suprachiasmatic nucleus (the "biologic clock")
Superior cervical ganglion

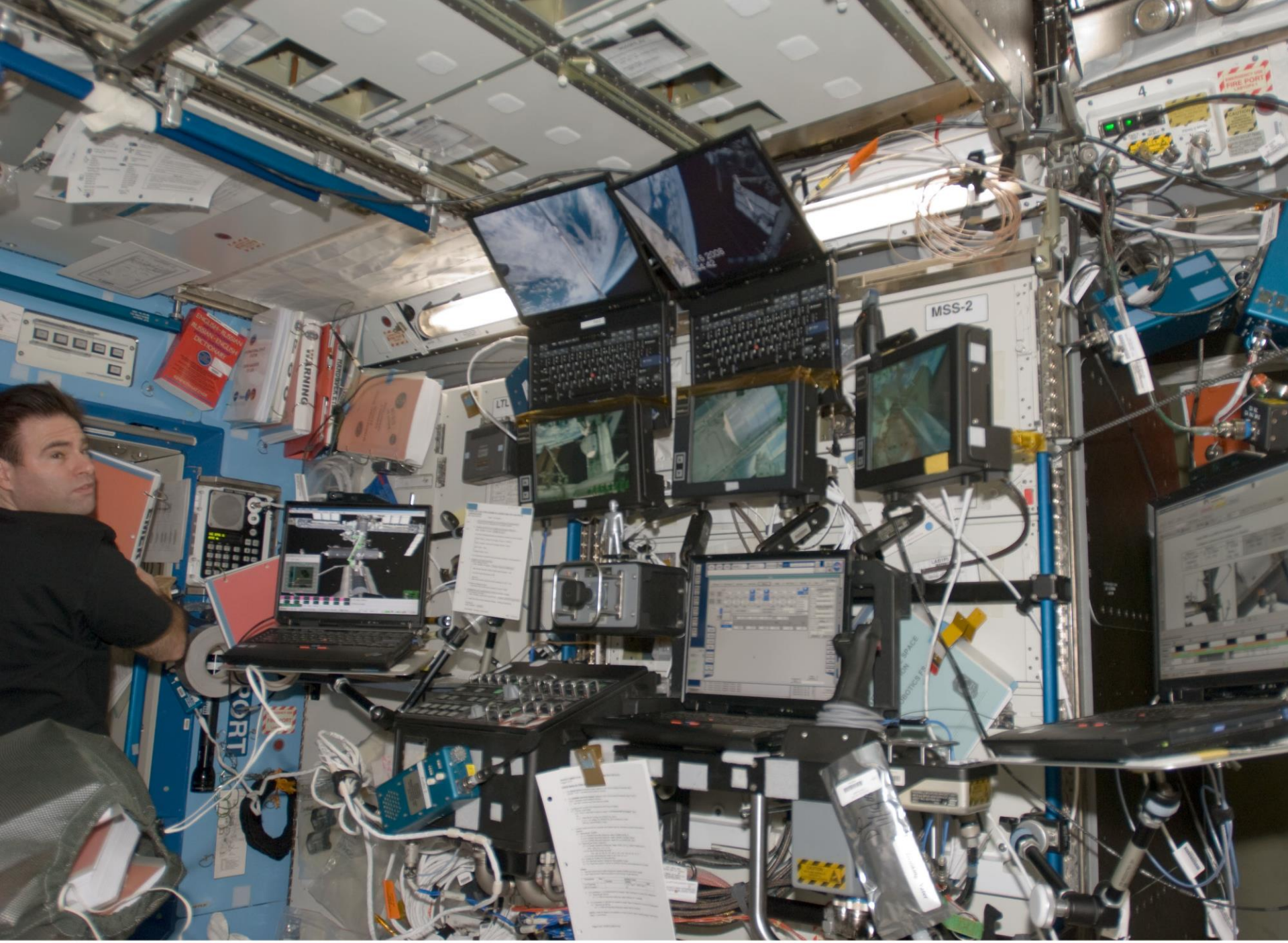
Spectral composition of skylight is heavily blue-weighted…

Peak *melanopsin* sensitivity is *480 nm* Peak *melatonin suppression 460 nm*




PHILIPS

With the goal of improving the alertness of flight controllers, we will determine what type of fatigue countermeasure will be the most feasible, acceptable and effective in this environment.



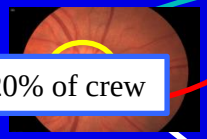
ISS018E008782

ISS Lighting and Robotics Analog
Center for Clinical Investigation, BWH

Spaceflight-Induced Idiopathic Papilledema/Vision Alteration

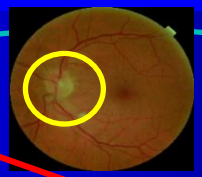
Some long duration crew members have various expressions of vision impairment/intracranial pressure. Both NASA's medical and research communities are pursuing options to mitigate this risk.

Optic Disc Edema

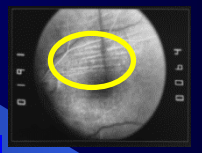


~20% of crew

Altered Blood flow
"cotton wool" spots on retina

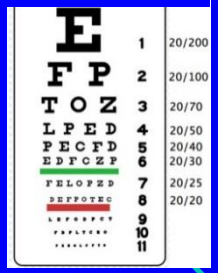


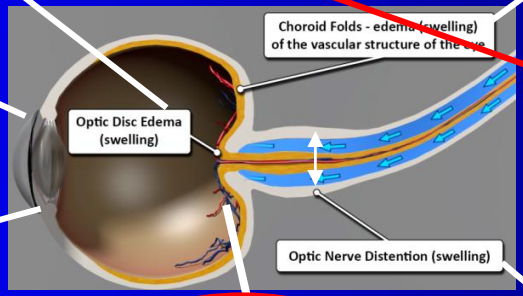
Choroidal Folds



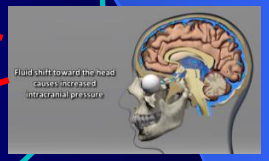
parallel grooves in the posterior

Hyperopic Shifts
-Up to +1.75 diopters



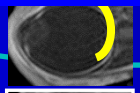


Increased Intracranial Pressure (ICP)



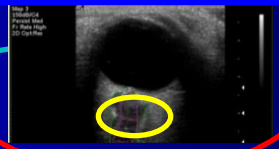
Scotoma
Altered Visual Field, rare (1 reported)

Globe Flattening



64% of crew

Increased Optic Nerve Sheath Diameter



Indicators of Elevated ICP

NASA's Medical Operations has an extensive Clinical & Occupational Surveillance Program to understand and mitigate the risk. Including development of advanced imaging diagnostics.

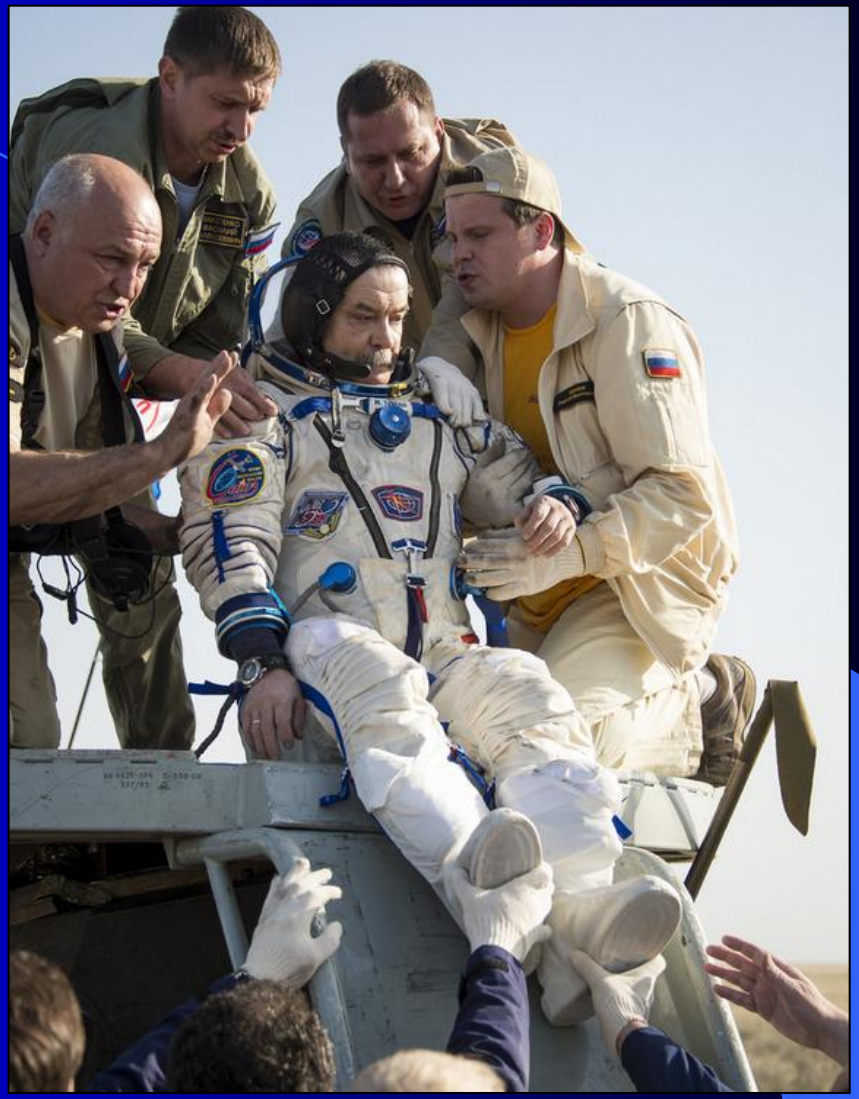
NASA's Human Research has numerous research protocols to investigate the phenomenon and also to develop advanced technology to non-invasively measure Intracranial Pressure (ICP) in spaceflight.

ronaut Pettit Performs Ultrasound Eye Imaging


United States


United States

National Aeronautics
and Space
Administration



National Aeronautics
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Administration

Medical Tent


03
24


NASA
N992NA

NASA 992

Capability:

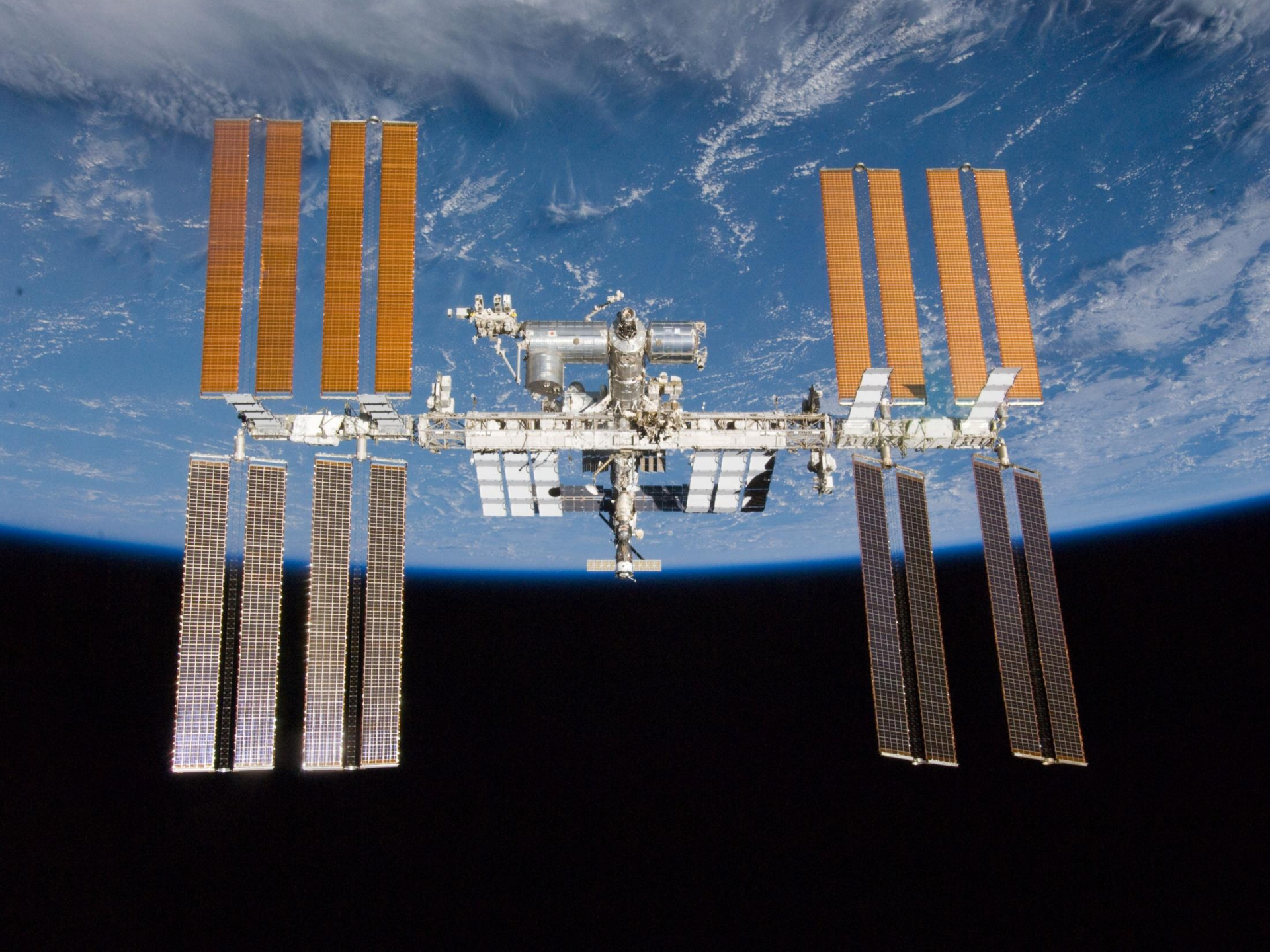
- ACLS
- Expected post flight symptoms
- Basic procedures – IV placement, Foley
- Some advanced procedures – airway
- Ultrasound
- Cooler for medical and research specimens

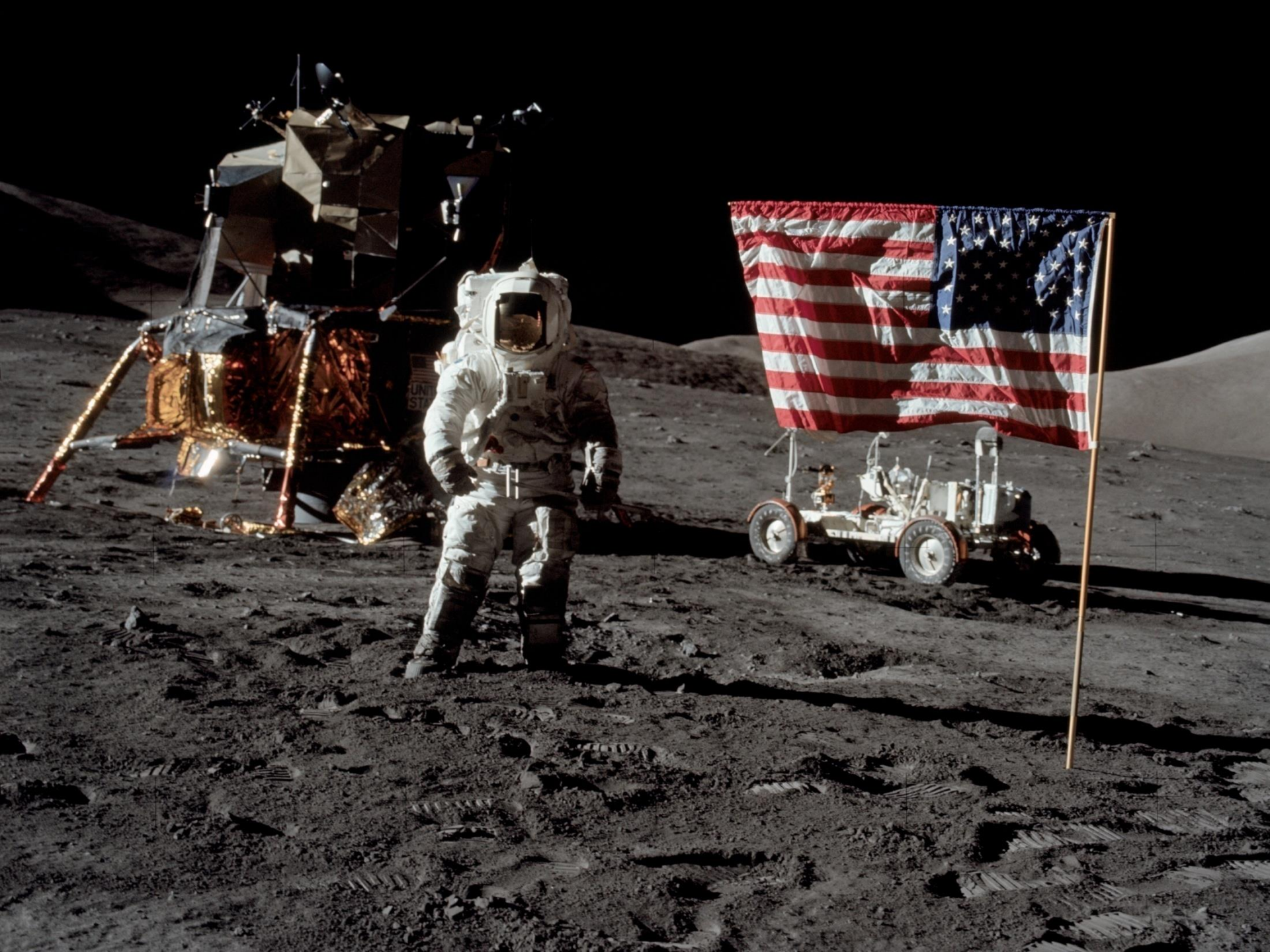
Astronaut Health

- Physical training and rehabilitation


KELLY
JOHNSON
CHAMITOFF
FINCKE
STS
134
AMS
Endeavour
FEUSTEL
VITTORI


DISCOVERY






USA
NASA